CONTRIBUTION TO A MAGNETITE CONSUMPTION IN THE KARVINÁ MINE'S PREPARATION PLANT OF THE LAZY PLANT

PŘÍSPĚVEK KE SPOTŘEBĚ MAGNETITU NA ÚPRAVNĚ DOLU KARVINÁ, ZÁVODU LAZY

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Abstract

In its introduction, this contribution deals with the usage of magnetite during the process of coal separation in the Karviná Mine's preparation plant of the Lazy Plant. Next it deals with the evaluation of quality of magnetite used in the preparation plant, losses of magnetite adhering to the products leaving the preparation plant, the recovery of a diluted suspension with focus on the efficiency of magnetite separation of the diluted suspension and the comparison of the magnetite consumption with the one in the ČSM preparation plant. In conclusions, the article presents options leading to the reduction of the magnetite consumption in the Karviná Mine's preparation plant of the Lazy plant. For comparison, the data of the ČSM Mine is stated here.

Abstrakt

Příspěvek se v úvodu zabývá použitím magnetitu při rozdružování těžného uhlí na úpravně Dolu Karviná, závodu Lazy, dále vyhodnocením kvality magnetitu používaného na úpravně, ztrátami magnetitu ulpívajícího na produktech odcházejících z úpravny, regenerací zředěné suspenze se zaměřením na účinnost separace magnetitu ze zředěné suspenze a porovnáním spotřeby magnetitu s úpravnou dolu ČSM. V závěru jsou uvedeny možnosti vedoucí ke snížení spotřeby magnetitu na úpravně Dolu Karviná, závodu Lazy. Pro porovnání jsou zde uvedeny hodnoty z Dolu ČSM.

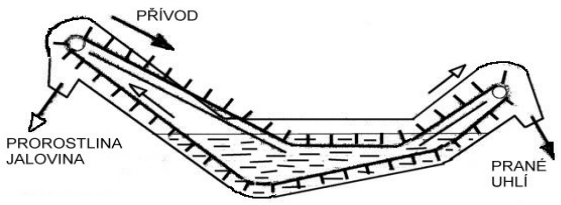
Key words: magnetite, coal, separation.

1 INTRODUCTION

In the Kariná Mine's preparation plant of the Lazy Plant, magnetite is used to treat coal. Magnetite is used as a high density material from which together with water a dense medium is prepared. The high density material must meet at least several conditions, such as availability, low cost, sufficient density, abrasion resistance, and may not react with the treated raw material and may not be soluble in water as well. The dense medium must have at least several properties such as high stability, low viscosity, wholesomeness and easy recoverability. The dense medium suspension is used to create an environment conductive to the separation of products. The separation is a process in which materials are separated due to their different properties, in our case their different density. The separation in the preparation plant of the Lazy Plant takes place in a SM (Staatsmijnen) dense medium separator (Fig. 1) and in hydrocyclones where coal, dirt band and spoil are separated from one another. The shallow SM dense medium separator consists of a bath where a scraper conveyor is located. The dense medium and the material being treated are fed to the bath.

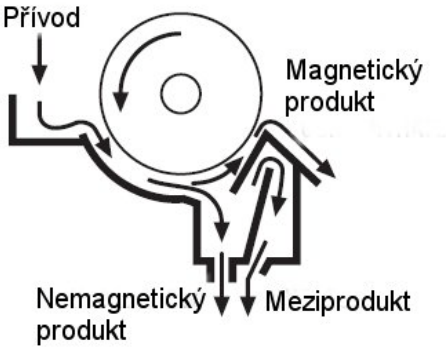
Through the upper branch of the discharge end floats are washed out (the fraction of lower density than the density of the dense medium) and through the lower branch of the discharge end sinks falling to the bottom of the bath are discharged (the fraction of higher density than the density of the dense medium). Dense medium cyclones are used to remove particles of smaller particle size where besides gravitational forces, as in a SM dense medium separator, also centrifugal field forces are applied.

The cyclone involves a tapered inlet through which the material is supplied together with the dense medium into a short cylindrical section followed by a conical section. The conical section ends with a tapered outlet through which the higher density fractions are discharged. In the axis of the dense medium cyclone there is an overflow outlet on top through which the lower density fractions pass out. During the separation, particles of the high density material adhere to the surface of the material being separated. If not removed, they can cause the deterioration of the quality of manufactured products and an increase in the consumption (losses) of the high density material. In order to minimize losses of the high density material (economically significant), the separation products are rinsed off, and so the adhered high density material removed from their surface. This way a mixture of particles of the high density material, fine particles of the material being separated and other foreign matters and water occurs which is referred to as a diluted suspension. For further use (re-use) of the high density material it is necessary to recapture its particles for the preparation of a new suspension. This technological operation is called dense medium recovery. [1] In the Lazy Plant, the recovery of magnetite particles is performed by multi-stage separation using magnetic separators. The principle of a uniflow magnetic separator is shown in Fig. 2. The choice of a recovery method for the diluted suspension depends on the type of the used high density material and its properties. As the high density material used by us has magnetic properties, we could use the properties to recover the diluted suspension. Regarding the price of magnetite has been increasing in recent years and the magnetite consumption in the Karviná Mine's preparation plant of the Lazy Plant amounts monthly to one million crowns on average, it is necessary to check regularly the magnetite consumption and simultaneously to seek ways to reduce it.



INLET
SPOIL WASHED COAL

Fig. 1 SM dense medium separator



INLET MAGNETIC PRODUCT
NON-MAGNETIC PRODUCT INTERMEDIATE

Fig. 2 Uniflow magnetic separator

2 PROPERTIES OF MAGNETITE USED IN THE PREPARATION PLANT OF THE LAZY PLANT

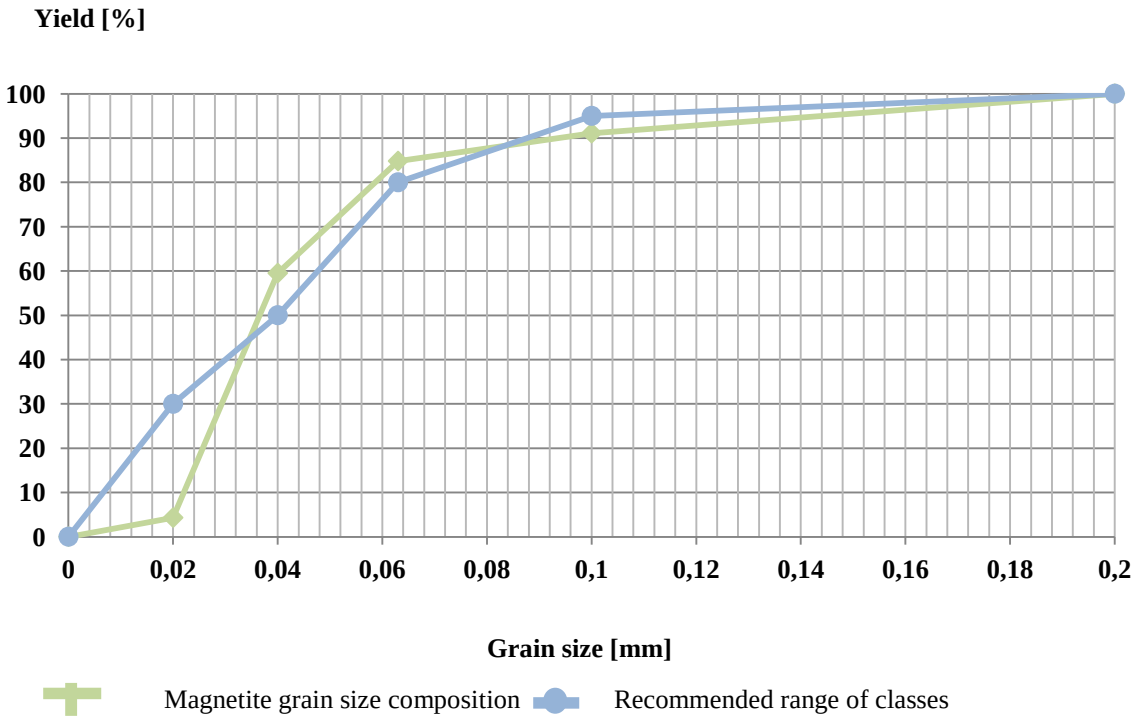
Raw magnetite was taken from a landfill plant of the preparation plant, and then its properties were determined in laboratories at the VSB-Technical University of Ostrava. These were the density of magnetite, its grain-size composition, contents of magnetic particles in raw magnetite and properties of raw magnetite. The properties were found in accordance with the industry standard 44 7233 - *Evaluating high density materials and separating suspensions*.

Density of magnetite - magnetite was first dried in an oven at 105°C. The dried magnetite was screened at a mesh size of 0.5 mm. From the undersize the magnetite density of 4524 kg.m^{-3} was determined by pycnometry. The density of magnetite complies with the conditions determined for high density materials.

Grain-size composition of magnetite - was determined by dry distribution on screens with nominal lengths of mesh of 0.1 mm, 0.063 mm, 0.04 mm and 0.02 mm. The grain size distribution of magnetite and the recommended range of grades used in coal preparation plants are given in Tab. 1. A graphical representation is presented in Graph 1. It follows from the values shown in the table or in the graph that magnetite does not differ much from the recommended particle size composition.

Tab. 1 Particle size composition of magnetite and recommended range of grades. [2]

Grain size [mm]	Magnetite weight [g]	Reality Magnetite yield [%]	Yield according to ON 44 72 33 [%]
- 0.020	1.157	4.3	30
0.020 - 0.040	14.768	55.2	20
0.040 - 0.063	6.7887	25.3	30
0,063 - 0,100	1.6778	6.3	15
+ 0.100	2.378	8.9	5
Total	**26.7695**	**100**	**100**



Graph 1 Particle size composition of magnetite and recommended range of classes. [2]

Determination of contents of magnetic particles and magnetic properties of raw magnetite - magnetic particle contents in raw magnetite was determined using the Mechanobr analyzer according to the industry standard 44 7233 which specifies the procedure for determining magnetic components. Magnetite contained on average 98.135 % of magnetic particles, which is a satisfactory value. The determination of magnetic properties of raw magnetite is voluntary. The procedure is imposed by the branch standard 44 7233. The observed average magnetic property of 0.76 is sufficient as it exceeds the value of 0.7 which is a recommended value according to the standard.

3 LOSS OF MAGNETIC FRACTIONS ON PRODUCTS

In the coal preparation plant, products already washed were taken after separation, i.e. those free of magnetic fractions. These were rinsed in the laboratory and the obtained mixture of slurry with remaining magnetite was subjected to control wet separation using the Mechanobr magnetic separator at the magnetic induction B = 0.1 T, level 2 and a voltage of 24 volts. The results are shown in Table 2. The reported losses are acceptable. The rinsing process can be considered effective if losses are not greater than 1 kg per ton of coal being processed, or per ton of charge. The different amounts of magnetite losses are caused by the different particle size of products and the associated size of the surface which the magnetite particles adhere to.

Tab. 2 Loss of magnetic fractions on products. [2]

Product	Loss [g/t]	Product	Loss [g/t]
Lumpy product	24.35	Dirt band	80.86
Coal from centrifuges	40.26	Fine stone	73.48
Washed coal	189.78	Rough stone	68.21
Dirt band from centrifuges	38.70	Spoil	45.16

For comparison, measurements at the ČSM Mine in 2010 under the same conditions showed higher losses of magnetite on products of dense medium cyclones at magnetic fraction contents of 97.94 % in dry magnetite. [3]

Losses of magnetic particles on DM HC products
Washed coal 322 g/t
Spoil 88 g/t
Losses of magnetic particles on DM HC products
Washed coal 391 g/t
Spoil 81 g/t
Losses of magnetite on DM HC products
Washed coal 328 g/t
Spoil 90 g/t
Losses of magnetite on DM HC products
Washed coal 399 g/t
Spoil 82 g/t

4 RECOVERY OF DILUTED SUSPENSION

Magnetite in the coal preparation plant of the Lazy Plant is recovered using drum magnetic separators. In order to ensure sufficient efficiency, a three-stage separation process is used. In the first stage of recovery, four separators are involved, in the second stage, six separators are included and in the third stage, four separators are used. The separator is a device consisting of a drum rotating in a bath which is fed with the diluted suspension. Non-magnetic particles are rinsed off through the opening of the environment being separated to the next stage of recovery or to a service water tank. Magnetic particles are attracted in the magnetic field to the drum surface, washed away from the diluted suspension into a chute area where they are rinsed off and drained into a tank of magnetic fractions. This way obtained magnetite is used for a new application. The efficiency of magnetic separation is shown in Table 3, and for comparison, the efficiency of magnetic separation at the ČSM Mine is given in Table 4, where the efficiency result is better than in the Lazy Plant for a lower value of magnetic particle contents in raw magnetite.

Tab. 3 Calculations of magnetic separation efficiency on separators. [2]

Indicator		Concentrate		Waste		Intake	
Contents of mag. fractions [%]	98.14	c	86.23	b	0.45	a	37.43
Yield [%]		vc	43.11	vb	56.89	va	100
Amount of magnetic portions [kg/10 t]		C	3717.64	B	25.36	a	3743
Contents of magnetite [%]		cr	87.87	br	0.45	ar	38.14
Contents of coal slurry [%]	slurry	cb	12.13	bb	99.55	ab	61.86
Sum			100		100		100
High density material		Cr	3788.28	Br	25.84	Ar	3814.11
Contents of slurry	slurry	Cb	523.04	Bb	5662.85	Ab	6185.89
Sum			4311.31		5688.69		10000
Yield [%]	Fe_3O_4	mc	99.23	mb	0.68	ma	100
Yield [%]	of slurry	wc	8.46	wb	91.54	wa	100
Efficiency [%]			90.87	+	-90.87	=	0.00

Tab. 4 Calculations of efficiency of magnetic separation on a ČSM Mine's separator in 2010

Indicator		Concentrate		Waste		Intake	
Contents of mag. fractions [%]	97.94	c	88	b	0.35	a	31.7
Yield [%]		vc	35.76	vb	64.24	va	100
The amount of magnetic portions [kg/10 t]		C	3147.52	B	22.48	a	3170
Contents of magnetite [%]		cr	89.85	br	0.36	ar	32.37
Contents of coal slurry [%]	slurry	cb	10.15	bb	99.64	ab	67.63
Sum			100		100		100
Yield [%]	Fe_3O_4	mc	99.29	mb	0.71	ma	100
Yield [%]	of slurry	wc	5.37	wb	94.63	wa	100
Efficiency [%]			93.92	+	-93.92	=	0

Tab. 5 Waste water

2011	Waste water [m^3]	Charge [t]	Loss of magnetite [kg]	Loss of magnetite [kg/t] of charge
JANUARY	46000	136300	13800	0.10
FEBRUARY	50670	147460	15201	0.10
MARCH	51570	155440	15471	0.10
APRIL	47290	183570	14187	0.08
MAY	41850	137430	12555	0.09
JUNE	43460	163419	13038	0.08
AVERAGE	46807	153937	14042	0.09
TOTAL	**280840**	**923619**	**84252**	**0.09**

5 CONCLUSIONS

The paper shows that the used magnetite is of good quality, losses of magnetite particles adhering to the surface of products being separated are minimal and the efficiency of magnetic separation is sufficient. In addition to technological subordination and regular inspections of the function of equipment in the preparation plant, a reduction of the magnetite consumption can be achieved by a limited discharge of waste water. In order to minimize the discharge of waste water, the water and slurry circuits in the preparation plant must work well. These circuits are interconnected. The waste water discharged from the Lazy preparation plant contains 0.3 g/l of magnetite on average. The magnetite contained in the waste water is irretrievably lost.

Table 5 presents the amount of waste water discharged from the preparation plant, the amount of processed coal, magnetite losses in kg and the expression of losses of magnetite in the waste water in relation to the currently processed amount of coal.

REFERENCES

[1] NOVÁČEK, J.: – *Technologie úpravy uhlí I*, VŠB – TU OSTRAVA, 2000

[2] TŘINECKÝ, D.: – *Vyhodnocení účinnosti regenerace magnetitu na dole Karviná, závod Lazy,* BAKALÁŘSKÁ PRÁCE, VŠB – TU OSTRAVA, 2011

[3] ŘEPKA, V. a kol.: - *Provedení garančních zkoušek hydrocyklonové linky B na OKD, a.s. VOJ Důl ČS*M HS 542003 RPS Ostrava, a.s. Ostrava

RESUMÉ

Magnetit slouží jako zatěžkávadlo, ze kterého se společně s vodou připravuje těžká suspenze. Důvodem použití suspenze je vytvořit prostředí sloužící k rozdružování produktů. Rozdužování je proces, kde dochází na základě rozdílných vlastností materiálů, v našem případě rozdílné hustoty materiálů, k jeho oddělování. Rozdružování na úpravně dolu Karviná, závodu Lazy probíhá v těžkosuspezním rozdružovači SM (Staatsmijnen)

a v hydrocyklónech, kde jsou od sebe oddělovány uhlí, proplástek a hlušina. Při rozdružování ulpívají částice zatěžkávadla na povrchu rozdružovaného materiálu. Nejsou-li odstraněny, mohou způsobit zhoršení kvality vyrobených produktů a současně představují spotřebu (ztráty) zatěžkávadla. Za účelem minimalizace ztrát zatěžkavádla (ekonomicky významné) jsou produkty rozdružování oplachovány, a tím je z jejich povrchu odstraňováno ulpělé zatěžkavádlo. Vzniká tím směs částic zatěžkávadla, jemných částic rozdružovaného materiálu i ostatních příměsí a vody, kterou označujeme jako zředěnou suspenzi. Pro další (opakované) použití zatěžkavádla je potřebné, částice zatěžkávdla ze zředěné suspenze znovu získat pro přípravu nové suspenze. Příspěvek se vedle popisu použití magnetitu na úpravně dolu Karviná, závodu Lazy, zabývá také oblastmi, které výrazně ovlivňují množství spotřeby magnetitu. Jedná se o tyto oblasti:

- *vlastnosti magnetitu používaného na úpravně závodu Lazy,*
- *ztrátami magnetických podílů na produktech,*
- *regenerací zředěné suspenze na závodě Lazy a porovnáním regenerací zředěné suspenze s dolem*

ČSM. Příspěvek se také zabývá odběrem a zpracováním vzorků v laboratořích VŠB – TO OSTRAVA, jejich vyhodnocením a hledáním cest vedoucích ke snížení spotřeby magnetitu na dole Karviná, závodu Lazy.

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